Session 15 Overview

Organic Devices and Circuits

Chair: Bill Bidermann, BK Associates, Los Gatos, CA

Associate Chair: Koji Kotani, Tohoku University, Sendai, Japan

Rapid advances in organic devices make possible a broad spectrum of circuits and systems that address needs from RFID devices to electronic paper that outputs Braille text for the blind. Though organic electronics will not displace silicon solutions, they promise to become ubiquitous in everyday life. Low cost sensors, flexible displays, electronic labels, smart tickets, anti-counterfeiting technologies and other "electronic paper" applications; all these and many other applications rely on the development of organic devices and circuits characterized in this session. The eight papers in this session portend the huge impact of these devices.

The session begins with two developments in RFID tag technology. Both transponders operate at 13.56MHz. Intended for use as a commercial item-level tag, the proof of concept device presented in Paper 15.1 scavenges its power from the incoming RF signal using organic diodes. The devices operate over distances up to 4.75cm using low cost printable polymers allowing volume production of tags for less than 5 cents per tag. The second paper, 15.2, describes RFID tags manufactured using a pentacene on plastic technology. The tag circuitry also operates at the de facto standard 13.56 MHz frequency. A second tag, using the same technology, incorporates full 64-bit tags and comprises almost 2,000 active devices.

Beyond RFID tags, Paper 15.3 demonstrates the diversity of applications to which organic transistors apply. An electronic "nose" sniffs vapors inside the packages of food and pharmaceutical products, in this case bottles of wine. These devices detect levels of acetic acid associated with wine spoilage at levels of 10 parts per million utilizing a bridge structure. Inkjet printing technology allows the low-cost production of devices required for this application.

Displays in flat panel TV's, laptop computers and many other products have become commonplace. A modifiable Braille display for the blind appears in Paper 15.4. The development of a 5-transistor SRAM cell allows the actuators in the Braille display to improve its update time from 34 seconds to 2 seconds. This exciting technical development allows one to envision a world where the blind can read electronic newspapers and novels in as timely a way as their sighted counterparts, possibly even the Advance Program for ISSCC!

Future products based on organic devices rely on the development of analog building blocks: cascode amplifiers, differential amplifiers, and differential-to-single-ended converters. Despite their performance lag relative to silicon devices, Paper 15.5 develops an empirical model for organic devices used to predict the statistical performance of these building blocks, including amplifiers with 10dB of gain and unity gain frequencies of 1.4kHz. Future development of switched-capacitor circuits will increase the proven topologies available to organic circuit designers.

The session wraps up with two papers. Paper 15.7, describes full complementary organic circuits (P and N-channel) that operate devices at voltages as low as 2 Volts. The inverter shows a gain of 14 and a noise margin of 0.65V. The final paper in the session, Paper 15.8, describes fabrication of more conventional low temperature polysilicon TFT CMOS circuits but deposits them directly on plastic substrates requiring maximum process temperatures less than 300°C. These 2µm channel-length devices produce ring oscillators operating at 100MHz.

15.1 Printable Electronics for Polymer RFID Applications **8:30 AM**
M. Böhm, PolyIC, Erlangen, Germany

An organic RF identification transponder operating at a carrier frequency of 13.56MHz is presented in a proof of concept IC with no ID. The rectifier and the digital integrated modulation circuit are based on organic p-type semiconducting material with a total transponder area of 4cm^2. The operational distance is 0 to 4.75cm while the clock frequency is 120Hz.

15.2 A 13.56MHz RFID System based on Organic Transponders **9:00 AM**
E. Cantatore, Philips, Eindhoven, The Netherlands

RFID tags using organic transistors are described: Two 8b tags carrying different codes, energized and read out at 13.56MHz, the defacto standard for item-level ID, have been tested and demonstrated to enable multiple-object identification for the first time; A 64b tag, the most complex organic transponder reported to date, operates at 125kHz and employs 1938 transistors.

15.3 Printed Electronic Nose Vapor Sensors for Consumer Product Monitoring **9:30 AM**
V. Subramanian, University of California, Berkeley, Berkeley, CA

Embedded sensors based on printed organic semiconductors are attractive for use in product content monitoring due to their low cost. Arraying multiple sensor elements in a bridge topology yields signatures that achieve high specificity using non-specific elements. The output signal is amplified and digitized to detect numerous analytes with up to 10ppm sensitivity. A wine-spoilage application is demonstrated.

15.4 An Organic FET SRAM for Braille Sheet Display with Back Gate to Increase Static Noise Margin **10:15 AM**
M. Takamiya, University of Tokyo, Tokyo, Japan

Organic FETs (OFETs) are integrated with actuators and a Braille sheet display is demonstrated. A back-gated OFET SRAM and the circuit technology for the Braille sheet display to enhance speed, yield and lifetime are presented along with essential elements for future large-area electronics made with OFETs.

15.5 Analog Signal Processing with Organic FETs **10:45 AM**
N. Gay, Dresden University of Technology, Dresden, Germany

Regular and differential amplifiers as well as differential-to-single-ended circuits based on organic FETs (OFETs) are demonstrated. A numerical OFET model suitable for analog design is developed. Unity-gain bandwidths in excess of 1.4kHz and dc-gains of 10dB are achieved.

15.6 Paper Withdrawn

15.7 A 2 V Organic Complementary Inverter **11:15 AM**
S. De Vusser, IMEC, Leuven, Belgium and Katholieke Universiteit, Leuven, Belgium

A complementary organic thin-film transistor technology uses pentacene and $F_{16}CuPc$ as the p-type and n-type materials, respectively. The semiconductors are patterned by vacuum deposition through an integrated shadow mask, while tilting the substrate. Organic complementary inverters are realized that display an almost ideal inverter curve at a supply voltage of 2V, showing a gain of 14 and a noise margin of 0.65V.

15.8 CMOS-on-Plastic Technology using Sequential Laterally Solidified Silicon Thin-Film Transistors **11:45 AM**
M. Kane, Sarnoff, Princeton, NJ

CMOS circuits are directly fabricated on plastic substrates using a process with a maximum temperature of 300°C. NMOS transistors with 2µm channel lengths have unity-gain frequencies greater than 250MHz, and CMOS ring oscillators operate at 100MHz with a 15V supply.